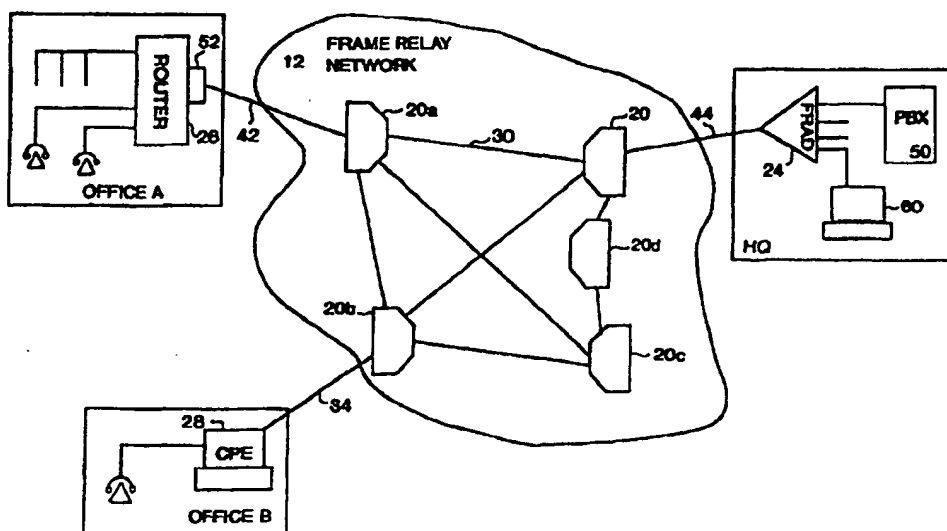


## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>H04L 12/56</b>	<b>A1</b>	(11) International Publication Number: <b>WO 98/09410</b> (43) International Publication Date: 5 March 1998 (05.03.98)
<p>(21) International Application Number: PCT/US97/15287</p> <p>(22) International Filing Date: 28 August 1997 (28.08.97)</p> <p>(30) Priority Data: 08/705,236 30 August 1996 (30.08.96) US</p> <p>(71) Applicant: CISCO SYSTEMS, INC. [US/US]; 170 West Tasman Drive, San Jose, CA 95134 (US).</p> <p>(72) Inventors: SIMON, Robert; 5150 Vista Bahia, Santa Barbara, CA 93111 (US). RUMER, Mark; 471 Mountain Drive, Santa Barbara, CA 93103 (US). LAND, Robert, A.; 216 Painted Cave Road, Santa Barbara, CA 93105 (US). SWANSON, David, E.; 7118 Del Norte Drive, Goleta, CA 93117 (US).</p> <p>(74) Agents: VINCENT, Lester, J. et al.; Blakely, Sokoloff, Taylor &amp; Zafman, 7th floor, 12400 Wilshire Boulevard, Los Angeles, CA 90025-1026 (US).</p>	<p>(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>With international search report.</i></p>	

(54) Title: ATM CELLS WITHIN FRAME RELAY TECHNOLOGY



## (57) Abstract

A frame relay communications network (12) consists of a number of interconnected nodes (20). The network nodes (20) include segmentation and reassembly means for fragmenting variable length frames (200) of user data into packets of a predefined length. A preferred embodiment uses ATM AAL5 segmentation and reassembly to construct cells. Header and trailer information is added to each of the cells for transport across the frame relay network.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

-1-

## **ATM CELLS WITHIN FRAME RELAY TECHNOLOGY**

### **FIELD OF THE INVENTION**

The present invention relates generally to the field of packet switching network communications and, more specifically, to the segmentation of large frames transported across such a network to enable fair and efficient use of trunk bandwidth.

### **BACKGROUND**

The desire to integrate data, voice, image and video over high speed digital trunks has led to the development of a variety of packet switching techniques. One such technique is called frame relay. A frame relay network provides a user with multiple independent data links to one or more destinations. User traffic on these data links is statistically multiplexed to provide efficient use of access lines and network resources. Since the multiplexing is at the link layer, end-to-end delay is minimized. Frame relay networks transfer user traffic without regard to content, thereby providing service which is effectively as transparent as a leased line. A frame relay network typically consists of a number of interconnected nodes which are capable of receiving data from other network nodes and forwarding that data through to other network nodes to its ultimate destination. Nodes are interconnected by transmission paths, each of which supports one or more virtual circuits. Communication from one user to another can thus be made using the pre-defined network connections of the virtual circuits.

Asynchronous Transfer Mode (ATM) is a second packet switching technology that provides users with the ability to connect to one or more users in a transparent fashion. Unlike the variable length packets used by frame relay services, ATM service is based on switching fixed length packets of data known as cells. Cell switching, as it is called, is gaining popularity for a variety of reasons. First, switch architectures can be optimized to switch cells at much higher speeds than variable length packets. Second, multiple services requiring a variety of quality of service guarantees can be provided simultaneously. ATM user traffic must be segmented into cells, transmitted, then reassembled back into

-2-

its original form. This segmentation and reassembly (SAR) process is done in a standardized way, regardless of the carrier providing the ATM service.

Although the use of variable length packets in frame relay can be more efficient in terms of overhead and bandwidth used when compared with the fixed length cells used in ATM, other problems, such as delay and latency, present themselves. In frame based environments, passing traffic from one end to another is somewhat unpredictable by nature. For example, if one virtual circuit is using a significant amount of bandwidth, it will have a tendency to choke out other sources. Also, if one virtual circuit is transporting relatively large frames through the network, other circuits with smaller frames may suffer. This is known as latency. For example, it is not uncommon for two sources, one transmitting large frames and the other transmitting smaller frames to be transported over the same wire. As the larger frame is being transported over the wire, the smaller frame will have to wait a relatively long period of time before it is transmitted on the wire. If both sources are transmitting latency insensitive traffic, e.g., data, this may not be a problem. However, if the smaller frame source is transmitting multimedia traffic (e.g., especially voice) which is very time sensitive, this latency can seriously degrade the quality of the service provided by the network. The latency problem is compounded if the wire is a relatively slow link.

One solution to the problems of latency and delay has been to fragment large frames into smaller packets for transmission through a frame relay network. Unfortunately, no standardized method of frame relay fragmentation has been adopted. As a result, a number of non-standard fragmentation schemes have been used. These non-standard fragmentation schemes lead to interoperability problems, generally resulting in increased user costs. In addition, for those users who do not have access to frame relay networks that use frame fragmentation schemes, the problems of latency and delay remain.

#### SUMMARY AND OBJECTS OF THE INVENTION

It is therefore an object of the present invention to provide a method for frame fragmentation within a frame relay network to reduce the problems of latency and delay.

It is an additional object of the present invention to allow the use of a single segmentation and reassembly method for both frame relay and ATM networks.

-3-

It is a further object of the present invention to provide an efficient means for data units to be converted between frame relay trunk traffic and ATM trunk traffic.

These and other objects of the invention are achieved by the use of ATM segmentation and reassembly methodologies in a frame relay network. A frame relay network consists of a number of interconnected nodes. Network nodes which utilize the invention include segmentation and reassembly means for fragmenting variable length frames of user data into packets of a predefined length. A preferred embodiment uses ATM AAL5 segmentation and reassembly to construct cells. Header and trailer information is added to each of the cells for transport across the frame relay network.

Other objects, features and advantages of the present invention will be apparent from the accompanying drawings and from the detailed description which follows.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references indicate similar elements, and in which:

Figure 1 illustrates a frame relay network incorporating the apparatus and methods of the present invention;

Figure 2 illustrates AAL5 segmentation and reassembly methodologies;

Figure 3 illustrates Frell formation using AAL5 methodologies according to one embodiment;

Figure 4 illustrates a Frell header according to one embodiment;

Figure 5a illustrates a Frell formatted for transport across a leased line according to one embodiment; and

Figure 5b illustrates a Frell formatted for transport across a public network according to one embodiment.

#### **DETAILED DESCRIPTION**

A method and apparatus to allow frame fragmentation in a frame relay network using ATM methodologies is described. According to one embodiment, in a frame relay network consisting of a number of interconnected nodes, variable

-4-

length frames of user data are fragmented into packets of a predefined length. One embodiment uses ATM AAL5 segmentation and reassembly methodologies to construct cell-like packets. Header and trailer information is added to each of the cell-like packets for transport across the frame relay network.

As shown in Figure 1, in a fully integrated frame relay network 12, a variety of switching nodes 20 - 20d are present. Each node 20 - 20d is interconnected to other network nodes 20 - 20d by a variety of transmission paths 30. (Note that for clarity only one transmission path 30 has been labeled. Those skilled in the art will appreciate that all of the transmission paths between network nodes 20 - 20d are substantially similar.) Each transmission path 30 supports a number of virtual circuits.

Access to frame relay network 12 is accomplished in a variety of ways. For example, a host 60 and a PBX 50 located at a central office HQ access frame relay network 12 via frame relay access device (FRAD) 24. FRAD 24 is coupled to a network node 20 via a leased line 44. FRAD 24 encapsulates transmitted data from host 60 into the frame relay format for transport through network 12 as specified by the Frame Relay User-to-Network Interface (UNI). As is known by those skilled in the art, FRAD 24 may be embedded in a bridge, a router (such as router 26 in remote office A), a multiplexer, or other stand alone device. Alternatively, FRAD 24 may be an expansion card with frame relay access functionality which is found within the chassis of host 60.

A local area network (LAN) located at Office A, accesses network 12 (as noted parenthetically above) via router 26. It will be appreciated that router 26 comprises a frame relay access device that performs the encapsulation function discussed above with regard to FRAD 24. A port 52 of router 26 is connected to a network node 20a via a second leased line 42, thereby allowing the LAN to access network 12.

Customer premises equipment (CPE) 28 at Office B has access to frame relay network 12 via leased line 34. It will be appreciated that CPE 28 has a frame relay access device incorporated within its chassis as an expansion card as described above.

The connections between the HQ, Office A and Office B and network 12 have been described as leased lines 34, 42 and 44. This is more accurately a description of the physical connections into network 12.

-5-

As described above, the variable length packets used in frame relay networks can lead to problems such as delay and latency. If any or all of lines 34, 42 and 44 are relatively low speed, then voice data will be delayed by frame relay data. For example, if host 60 generates a large frame relay frame, and FRAD 24 places that frame on line 44, voice traffic from PBX 50 will have to wait until the frame relay frame has been sent across line 44. If line 44 is running at 64K bits per second, and a 4K-byte frame is sent, the voice traffic could be delayed for up to 1/2 second. This will cause a lengthy distortion in the voice traffic at the receiving end. To overcome these problems, the present invention provides a means for fragmenting frames into smaller packets for transmission through frame relay network 12. Unlike fragmentation methods of the prior art, however, the present invention allows the use of segmentation methodologies adapted from ATM networks.

In ATM theory, an ATM Adaption Layer (AAL) performs a segmentation and reassembly (SAR) function. During transmission, higher level services pass user data to the AAL where, first, a convergence sublayer forms convergence layer protocol data units (CS-PDUs). These CS-PDUs will, generally, be larger than the payload capacity of an ATM cell. Therefore, a second sublayer, the segmentation and reassembly (SAR) sublayer, accepts the variable length CS-PDUs and fragments them into appropriate payloads (48 octets) for transmission. These payloads are referred to as segmentation and reassembly protocol data units (SAR-PDUs) and are passed to lower layers in the ATM protocol model for further processing. During reception, a reverse operation takes place and the SAR sublayer is responsible for reassembling messages as they are received.

Several ATM AALs have been developed for various applications. AAL Type 5 (AAL5) was designed for variable bit rate, connection-oriented services and provides good error detection capabilities and high line efficiency. The AAL5 methodologies are illustrated in Figure 2. During transmission, a user message 100 is passed from higher level protocols to the AAL, where it is referred to as an AAL Service Data Unit (AAL-SDU) 102. As shown in Figure 2, the AAL5 convergence sublayer uses the AAL-SDU 102 to create variable length protocol data units (CS-PDUs) 104. The CS-PDUs are made up of the following fields. The User Data Field 106 comprises data from the higher layer protocols and may be up to 65,536 octets in length. The Pad field 108 is used to align the entire CS-

-6-

PDU 104 on a 48-octet boundary (i.e., the entire CS-PDU 104 is a multiple of 48-octets in length). The Control field 110 is two octets in length and is presently reserved for future use. The Length field 112 indicates the actual length of the User Data Field 106 and is two octets long. The CRC-32 field 114 is appended to provide error detection in the CS-PDU 104.

CS-PDUs are passed to the AAL5 SAR sublayer. The SAR sublayer fragments the CS-PDUs to fixed-length SAR-PDUs 116, each 48-octets long. There are no new headers or trailers added by the SAR sublayer in AAL5. No padding is necessary because the CS-PDU 104 was padded to a multiple of 48-octets. As further shown in Figure 2, the SAR-PDU 116 is passed to the ATM layer where a 5-octet header 118 is added to form an ATM cell 120.

The present invention takes advantage of the SAR methods provided by AAL5. To avoid latency and delay, stand-alone FRAD 24 and embedded FRADS 26 and 28 implement frame fragmentation according to AAL5 SAR methodologies. (Those skilled in the art will appreciate that while AAL5 is used in one implementation, other ATM AAL SAR methodologies could also be used.) More specifically, user frames of data are transmitted to a FRAD (e.g., FRAD 24) where the frame is buffered. Each frame is then processed by a SAR unit within the node such that the variable length frame is fragmented into multiple 48-octet PDUs as described above. The fragmentation is performed according to the AAL5 procedure described above.

Figure 3 illustrates this process. A user frame 200 is transmitted from host 60 to FRAD 24, for example. At FRAD 24, the user frame 200 is buffered until it can be serviced. When the frame is serviced, it is passed to a SAR unit within FRAD 24. Within the SAR unit, the frame 200, now referred to as a User-SDU 202, has trailer information 204 appended to create a CS-PDU 206 as described above. The CS-PDU 206 is then fragmented into fixed-length SAR-PDUs 208, each 48-octets long. The fragmentation procedure follows the same AAL5 methodology described above.

Each SAR-PDU 208 has a 2-octet header FH 210 appended to form a 50-octet packet 212. The format of these headers 210 is shown in Figure 4. The header contains fields for 10-bits of connection information (VCI, VPI); 3-bits of payload type (PTI); and a cell loss priority (CLP) bit. The 50-octet packets are



-7-

referred to as "Frells" 212, a name which implies the cell-like (from ATM) attributes of the frame relay packets.

Once each Frell 212 has been assembled, it is passed from the SAR unit for transmission across frame relay network 12. In particular, each Frell 212 is transported (according to the VPI, VCI header information) to an appropriate port within FRAD 24. At the port, an HDLC controller appends further header and trailer information required for transport to frame relay network 12. Frame relay Flags are added to each Frell as headers and trailers. In addition, two CRC-octets are added prior to the Flag trailer. If the Frell is to be transported over a public frame relay network, e.g. frame relay network 12 in Figure 1, then a 2-byte encapsulating frame relay header (EFH) 218 is added at the beginning of the Frell, prior to the Frell header. The resulting packet is then ready to be transmitted through the Frame Relay Network to a destination node. Figure 5a shows the format of the 52-octet packet 214 for transmission across a leased line while Figure 5b shows a 54-octet packet 216 with an EFH 218 added for transmission across a public frame relay network. Those skilled in the art will realize that when one Frell is immediately followed by another Frell, only one Flag octet need separate the two Frells.

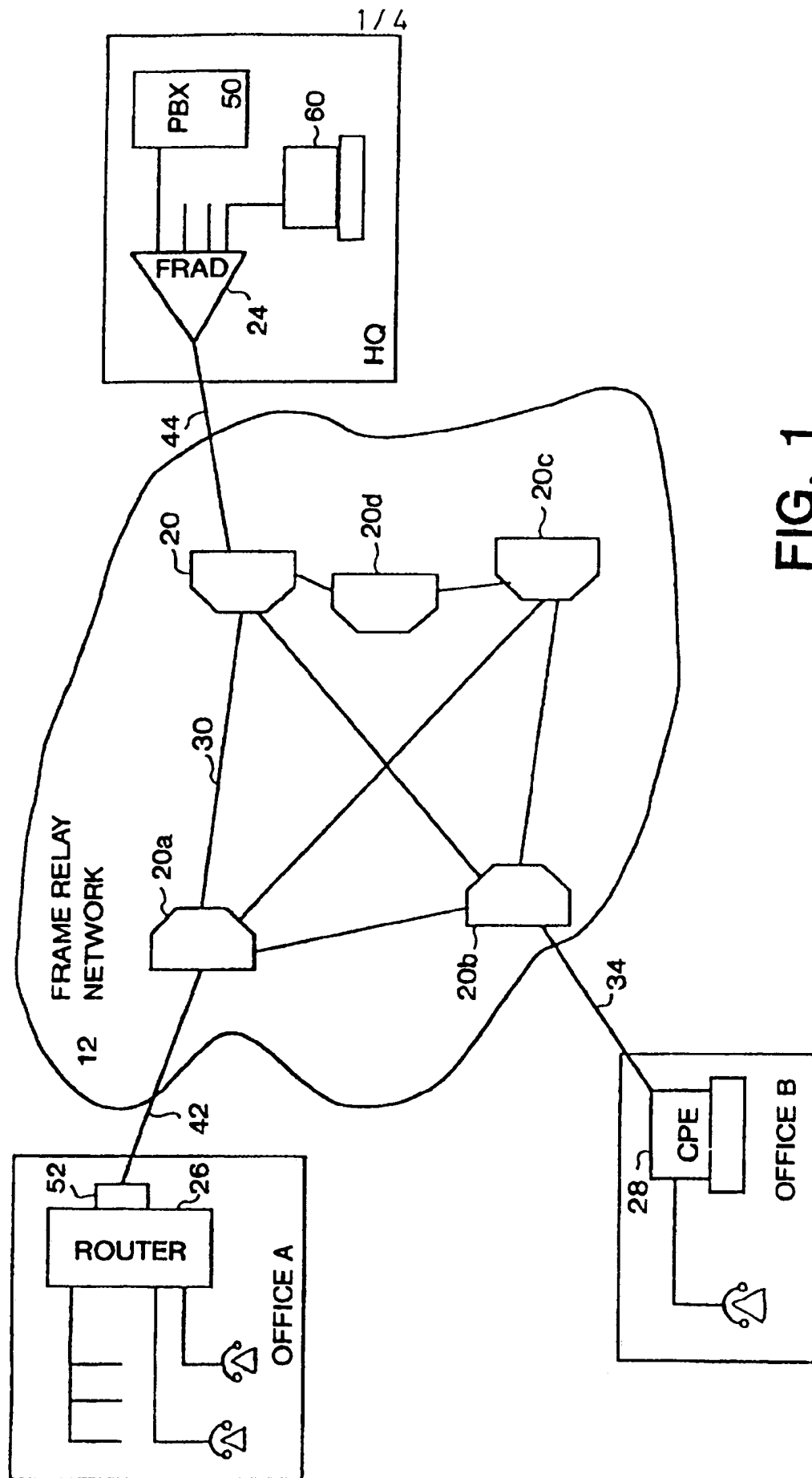
At the destination node, as each packet is received, an HDLC controller validates the CRC and strips off the Flag bytes and the CRC bytes. The remaining Frell is then associated with other Frells from the same original user data frame and the frame is reassembled according to AALS methodologies. When the frame has been reassembled, it is transmitted from the destination node to the destination user for further processing.

Thus, a method and apparatus for providing ATM segmentation and reassembly methodologies in a frame relay network has been described. In the foregoing specification, the invention has been described with reference to specific exemplary embodiments thereof. It will, however, be clear that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

CLAIMS

What is claimed is:

1. In a frame relay communications network comprising a plurality of nodes, the nodes being interconnected by a plurality of point-to-point links, a method of automatically fragmenting user data frames into packets having a fixed length, the method comprising the steps of:
  - receiving at a first node of the plurality of nodes a user data frame, the user data frame having a first length;
  - segmenting the user data frame into a plurality of packets, each of the packets having a predetermined length, the segmenting comprising ATM Adaption Layer methodologies;
  - appending to each of the packets a header, the header comprising network routing information; and
  - transmitting the packets from the first node to a second node of the plurality of nodes.
2. The method of claim 1 wherein the segmenting comprises ATM AAL 5 methodologies.
3. The method of claim 2 wherein the header comprises virtual circuit information, payload type information, and cell loss priority information.
4. The method of claim 3 wherein said step of transmitting comprises appending beginning-of-frame, end-of-frame and error detection information to the packet and transmitting the packet across the frame relay communication network.
5. A frame relay access device comprising a segmentation engine, the segmentation engine employing ATM methodologies for segmenting variable length user data frames into packets, said packets having a predefined length.
6. A frame relay access device as in claim 5 wherein said ATM methodologies comprise ATM AAL 5 segmentation methodologies.



2 / 4

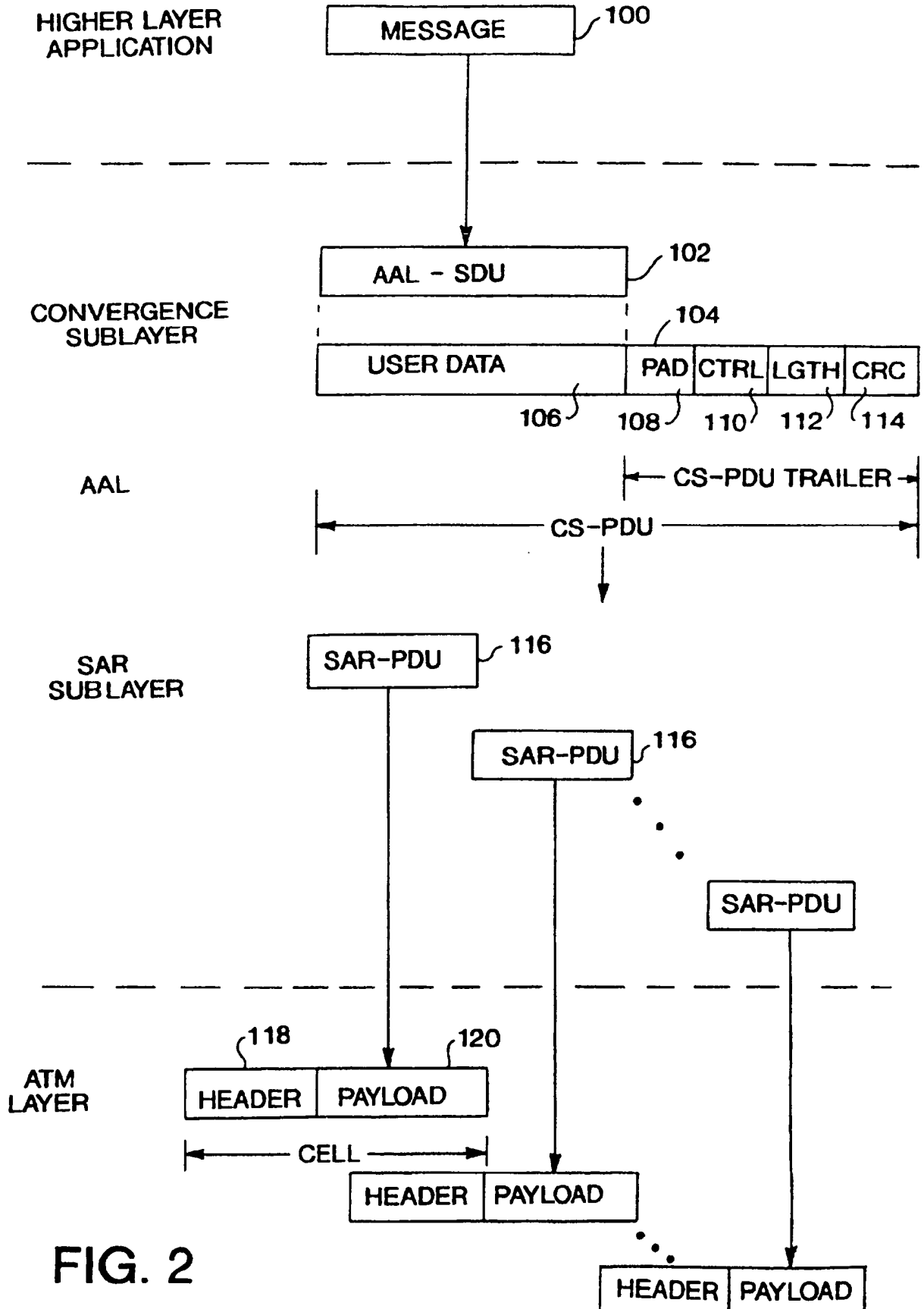
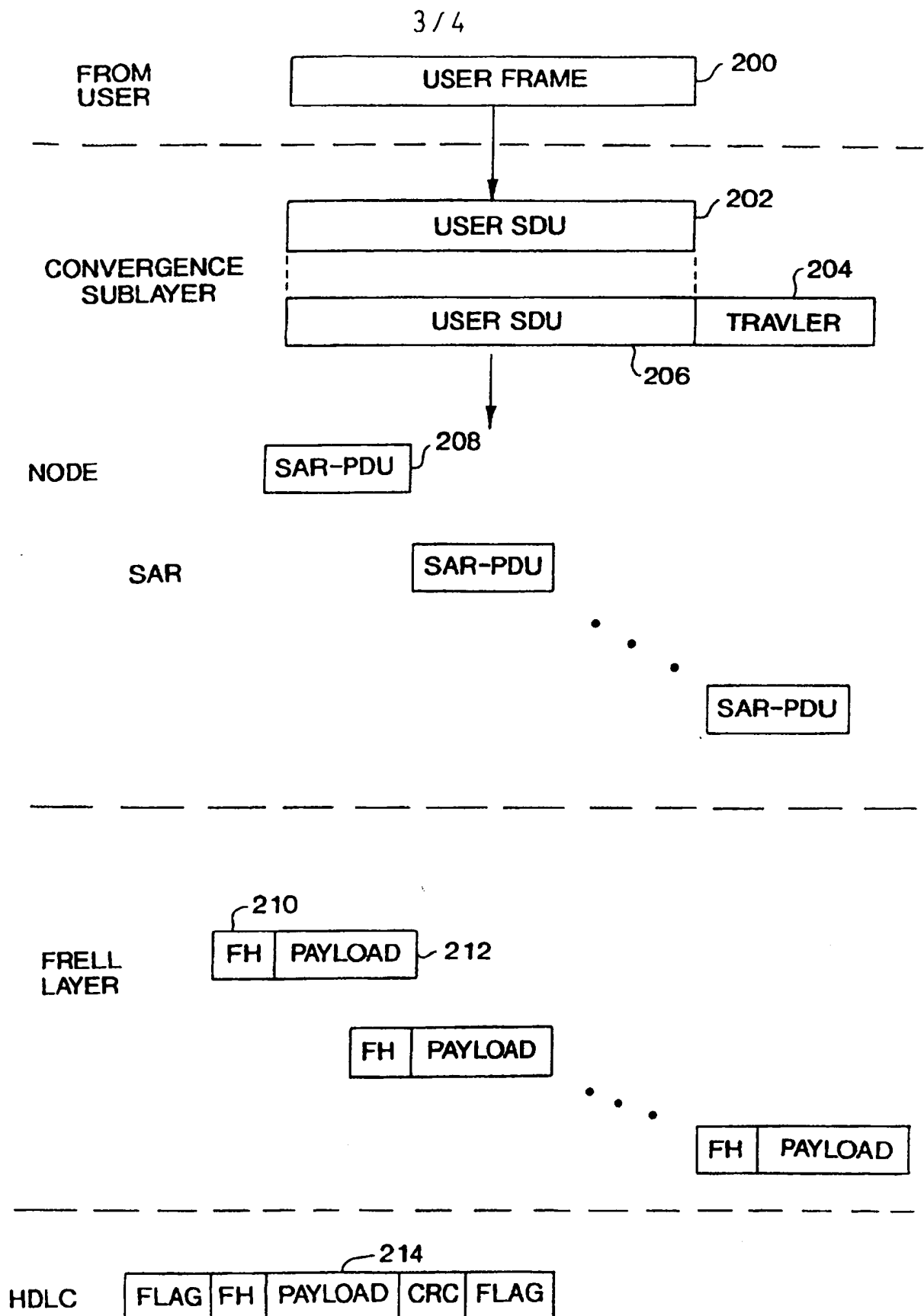


FIG. 2

**FIG. 3**

4/4

VCI (5-4)	VPI (3-0)	PTI (2)	0
VCI (3-0)	PTI (1-0)	CCP	1

210

FIG. 4

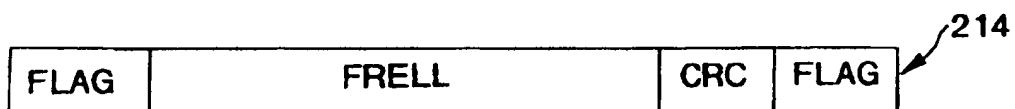


FIG. 5A

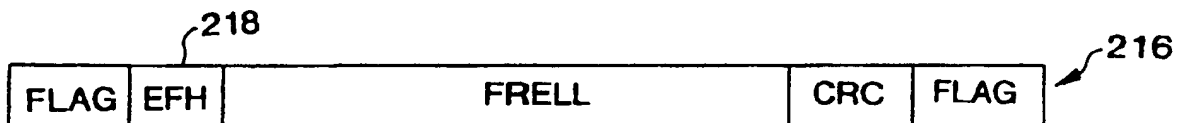


FIG. 5B

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US97/15287

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04L 12/56

US CL :370/395, 396, 397, 465, 474

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 370/395, 396, 397, 465, 474

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,490,140 A (ABENSOUR et al) 06 February 1996, col. 7-8.	1-6

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E* earlier document published on or after the international filing date	*Y* document of particular relevance; the claim-d invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G* document member of the same patent family
*I* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 02 OCTOBER 1997	Date of mailing of the international search report 17 NOV 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer CHAU T. NGUYEN Telephone No. (703) 308-5340